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FREE FALL SIMULATOR

The present invention relates to a free fall simulator, in other words an installation for keeping a person in
5 equilibrium in a free fall position in a controlled flow of rising air which passes through a maneuvering chamber.

A free fall simulator of this type has been designed for multiple purposes, including training and education of
10 parachutists or sports enthusiasts, and has even been applied in theme parks. Clearly, this type of free fall simulator makes it possible to avoid all the problems of cost and meteorological uncertainties associated with the obligation regarding normal practice when diving from an
15 aircraft at altitude.

The object of the present invention was therefore to provide an improved free fall simulator which is capable of generating a rising air flow at decreasing speed. Such
20 an air flow has to be as homogeneous as possible to enable any user, regardless of his weight and build, to move through his equilibrium positions and free fall configurations at different equilibrium heights. To enable the user to learn effectively how to change the attitude and orientation of his body to control the speed
25 and direction of motion of his fall, it is essential to generate a rising air flow which is as homogeneous as possible within the maneuvering chamber. Such an installation must of course also meet a number of other
30 constraints relating to environmental protection, and more particularly relating to soundproofing.

This is why the present invention relates to a free fall simulator which is characterized in that it comprises:
35 > a lower compression chamber:
 • in the vicinity of whose lower periphery there

open the outlets of a plurality of fans arranged in a centripetal configuration, and

- in whose upper tapered part there is placed a compression grid;

5 > a cylindroid chamber delimiting a maneuvering space, which is located immediately above the compression chamber, and which is designed to be traversed by a homogenous flow of rising air having a speed gradient decreasing regularly from the bottom to the top; and

10 > a generally cylindrical superstructure which encloses at least the maneuvering chamber of the simulator, which terminates in its upper part in a dome covering said maneuvering chamber of the simulator, and which is arranged to promote a downward circulation of the air leaving the

15 maneuvering chamber toward the fan inlets.

According to the present invention, the inner surface of

20 the compression chamber must be shaped to generate a homogeneous air flow which is essential to ensure the stability of the operator in the maneuvering chamber.

A certain number of specific characteristics relating to

25 the design of this compression chamber will become clear from reading the detailed description provided below, particularly with reference to the attached drawings showing schematically a free fall simulation installation of this type.

30 Further characteristics relating to the maneuvering chamber of the simulator will also become clear from reading the following detailed description.

35 The free fall simulation installation according to the invention comprises a superstructure part 10 comprising a

dome 12 protecting the maneuvering cylinder itself 14.

In the attached drawing, the superstructure part is extended by a schematic representation of attached
5 buildings 16 designed to house changing rooms, sanitary facilities and access corridors for the maneuvering chamber 14, an extension which can be provided equally well on either side of the dome 10. In the attached drawing, the line 18 indicates schematically the
10 approximate ground level.

Below this level 18, the installation comprises an substructure part essentially consisting of an annular machine room 20 for the introduction of air, together
15 with the lower compression chamber 22.

The lower compression chamber 22 has in the vicinity of its lower periphery a plurality of apertures into which there open the outlets of centrifugal fans 24 arranged in
20 a centripetal configuration. This lower part of the compression chamber 22 is advantageously made in the general shape of a cylindrical solid of revolution 26 extended upward by a truncated conical part 28.

25 To generate a homogenous air flow both in the compression chamber 22 and especially in the maneuvering chamber 14 subsequently, it is advantageous to arrange the propeller fans 24 with a constant angular spacing.

30 In practice, it has been found satisfactory to use twelve centrifugal fans installed in the annular machine room 20 with a constant angular spacing.

In the illustrated embodiment, the compression chamber 22
35 has a radius of 7.75 m and a height of 7.5 m. The shape of this chamber makes it possible, in particular, to

generate air speed curves which are as homogeneous as possible.

5 In order to avoid the separation of the air stream along
the inner wall of the truncated conical part 28 near the
compression grid 30 arranged in the upper tapered part of
the truncated conical part 28, it was found useful to
equip the inner wall with an annular bend 32 projecting
10 toward the inside of the compression chamber 22. In the
illustrated embodiment, the annular bend has a radius of
1 m. This characteristic profile of the inner wall of the
compression chamber 22 makes it possible to channel the
air flow and to efficiently convert the static pressure
15 of the chamber to dynamic pressure without causing the
separation of the air stream after its passage through
the annular bend 32. This bend has a radius of
approximately 1 m and is preferably made in the form of a
galvanized sheet steel component which is perfectly
20 matched to the structure of the concrete walls of the
lower compression chamber.

The fans placed in the room can consist of centrifugal fans
of the type having an inlet funnel protected with a grid,
for introducing air which travels through apertures formed
25 in the periphery of the annular machine room 20. In the
conditions of embodiment of the illustrated installation,
the air flow speed in this annular section and at the fan
inlet will preferably remain less than 7 m/s.

30 The propeller fans will advantageously be mounted on
pedestals and anti-vibration blocks. The characteristics
of the fans which have been used successfully in practice
can be, for example, as follows:
unit air flow rate: $66 \text{ m}^3/\text{s}$;
35 fan pressure: 2,260 Pa.

The air outflow speed from this type of fan should advantageously be in the vicinity of 40 m/s.

- 5 The compression grid 30 fitted after the annular bend 32 has the principal function of maintaining the pressure of the lower compression chamber 22 and distributing as uniformly as possible the air speeds at the outlet of this compression chamber.
- 10 Advantageously, the compression grid 30 which is mounted in the upper part of the lower compression chamber 22 is designed to generate a pressure drop of approximately 150 Pa. In practice, a grid having a mesh size of 500 mm x 500 mm and, for example, a wire diameter of approximately
- 15 2 mm has been found entirely satisfactory.

- To complete the description of the lower substructure part of the installation according to the invention, we should mention that there must be constant air renewal
- 20 24, principally in order to counteract the overheating of the air due to the operation of the fans and to supply clean air regularly. For this purpose, in a particular embodiment, the upper part of the dome 12 has at least one fresh air intake fitted with a sound trap.
- 25 Furthermore, air extraction is provided mechanically by a plurality of extractor fans which also enable the temperature of the whole flight simulator to be controlled.

- 30 Sound traps can advantageously also be provided at the outlets of the extractor fans.

- In all circumstances, fresh air inlets and outlets should be provided in this installation and should be arranged
- 35 for operation in opposition.

The compression grid 30 is surmounted by a cylindroid chamber 36 delimiting a maneuvering space, located immediately above the compression chamber 22. This cylindroid chamber 36 is designed to be traversed by a homogeneous rising air flow having a speed gradient decreasing regularly from the bottom to the top.

Advantageously, this cylindroid maneuvering chamber 36 comprises a generally cylindrical bottom part 38 which is extended upward by a diverging conical part 40.

Advantageously, the angle formed by the walls of the diverging conical part 40 with the vertical is less than approximately 6° .

In the embodiment schematically shown, the total maneuvering height is of the order of 7 m. This total maneuvering height extends between the two safety nets 42 and 44 fitted, respectively, to the bottom and top parts of the cylindroid maneuvering chamber 36, when the intermediate comfort net 43 is removed.

The bottom part of this cylindroid maneuvering chamber 36 consists, in the installation shown in the attached figure, of a cylinder 3.80 m in diameter with a height of 2 m. The diverging conical part 40 has a height of 8.50 m with an angle of divergence from the vertical of approximately 3.6° . In practice, this angle has made it possible to avoid the wall effects and the separation of the air stream along the cylindroid maneuvering chamber 36.

It will be noted that, in these conditions, the bottom safety net 42, fitted approximately 1.5 m from the compression grid 30 and above the latter, contributes to a total pressure drop for the compression grid and safety

net of the order of 400 Pa.

Users of the installation can therefore maneuver through a height of approximately 7 m between the bottom protective net 42 and the lift limit located approximately 50 cm below the upper protective net 44.

In order to facilitate the outflow of air at the outlet of the cylindroid chamber 36 and thus enable it to be correctly recycled, the upper free edge of the cylindroid chamber 36 is provided with a peripheral collar 46 which can also be made from galvanized steel sheet in the form of a conversion component. Clearly, the annular bend 32 and the peripheral collar 46, made for example from galvanized steel sheet, together with the safety nets 42 and 44 and the compression grid 30, will be installed without the use of any fixing devices which might perturb the outflow of the fluid.

In the illustrated embodiment, the speeds are distributed within the cylindroid maneuvering chamber 36 as follows:
bottom part: approximately 70 m/s
median part: approximately 50 m/s
top part: near the limit lift speed of approximately 45 m/s.

It should be noted that the air speed generated in the bottom part, namely approximately 70 m/s, allows most free fall maneuvers to be carried out by experienced operators. Beyond this region, the speed decreases to the limit lift speed in the upper section of this chamber 36. The intermediate section corresponds in fact to the most widely used speed for operators with an average level of experience. This speed, of approximately 50 m/s (180 km/hr), will in particular be complied with at the top point of the platform 48 for access to the cylinder,

which is located at the level numbered 48 on the attached drawing.

5 At this level of the cylindroid chamber, the invention has a certain number of characteristics which are not shown in greater detail, and which are intended, in particular, to allow access to the maneuvering chamber.

10 Thus, the cylindroid maneuvering chamber is provided with an additional comfort net 43, fixed removably to its periphery.

15 According to another characteristic of the invention, the wall of the median part of the cylindroid maneuvering chamber has at least one aperture opening into a closed access chamber 52 in the dome and delimiting an access platform 48, preferably having the shape of a cylindrical solid of revolution.

20 According to another characteristic of the invention, the upper part of the access chamber 52 has a curved connecting profile 54, with an inward concavity to promote the circulation of the air flows.

25 According to another characteristic of the invention, the additional comfort net 43 is positioned substantially at the level of said access platform 48.

30 According to another characteristic of the invention, at least one peripheral net 56 allowing the operators to remain in the air flow is stretched over said aperture in the extension of the wall of the diverging conical part 40.

35 According to another characteristic of the invention, two peripheral nets 56 overlap each other at least partially

in order to allow the operators to access the maneuvering chamber.

5 According to another characteristic of the invention, the inner wall of the conical chamber 40 comprises a take-off and damping border 58 whose inner face extends in the extension of said inner wall of the conical chamber 40.

10 The homogeneity of the rising air flow in the cylindroid chamber 36 is also promoted by good recirculation of the air flow within the superstructure and substructure of the installation, the air flow passing through the annular chamber 20. This air circulation is indicated schematically by different arrows on the attached
15 drawing. To promote this air circulation, the superstructure is provided with a profiled central projection in the form of a solid of revolution 50 which is centered on the axis of revolution of the cylindroid maneuvering chamber 36. Advantageously, this profiled
20 central projection in the form of a solid of revolution 50 takes the general shape of a cone whose lateral surface is concave with a concavity directed toward the interior of said projection.

25 This arrangement promotes changes in the direction of the air at the outlet of the cylindroid chamber 36.

Clearly, the simulator described above can also comprise a certain number of modifications and/or additions
30 without thereby departing from the scope of the present invention.

Thus, it is possible to provide for the presence of ventilation openings and/or devices to reduce the
35 internal temperature of the installation.

The use of extractors to suppress noise inside and outside the installation can also be envisaged for certain conditions of use.

- 5 The use of any additional grids for diffusing and/or stabilizing the air flow can also be envisaged within the scope of certain specific applications of the simulator according to the invention.